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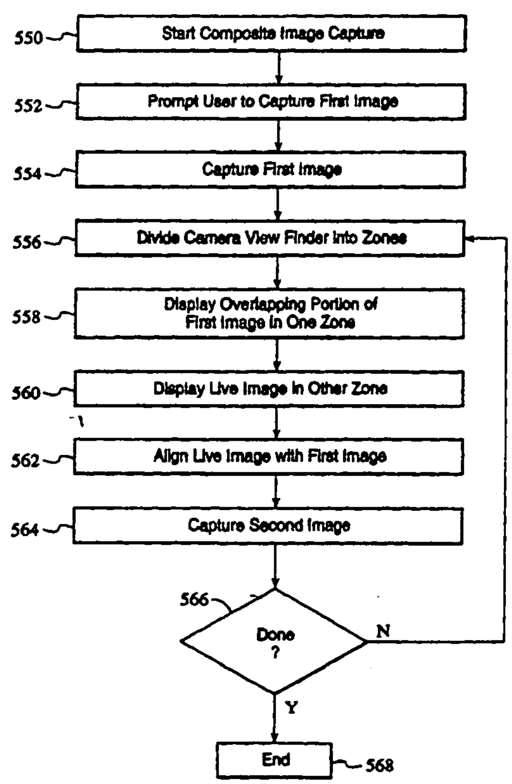
(57) Abstract

A method and system for assisting a user in manually capturing overlapping images for composite image generation using a camera (110). The method and system includes dividing the view finder (402) into a first and second zone (556) in response to the user capturing a first image (552). The portion of the first image (440a) that is to overlap with the next image is then displayed (558) on the first zone (A) of the view finder (402), while a live image is displayed (560) in the second zone (B). The two zones of the view finder thereby enable the user to align (562) the live image with the first image before capturing (564) the next image.



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A METHOD AND SYSTEM FOR ASSISTING IN THE MANUAL CAPTURE OF OVERLAPPING IMAGES FOR COMPOSITE IMAGE GENERATION IN A DIGITAL CAMERA

FIELD OF THE INVENTION

The present invention relates generally to digital cameras, and more particularly to a method and system for assisting a user to manually capture overlapping images for composite image generation.

BACKGROUND OF THE INVENTION

In the field of photography, a single composite image may be generated from a series of overlapping photographs. There are several types of composite images. For example, a "panorama" is an image created from a series of overlapping photographs that were taken while the camera is rotated less than 360 degrees, while a "virtual world" is created from a series of photographs that were taken while the camera is rotated 360 degrees.

Specialized equipment has typically been required to generate such composite images. This is because the photographs used to generate the composite image must be overlapped in a manner that sufficiently aligns the images both horizontally and vertically. Such alignment is necessary to allow a software program, called a stitcher, to appropriately "stitch" the images together to form the composite image.

The type of extra equipment necessary to align the overlapping images typically includes a tripod and a mechanical alignment device fitted between the camera and a tripod that mechanically rotates the camera into pre-set positions. This equipment enables a user to take a picture at each pre-set position, which automatically provides properly aligned overlapping photographs. After the photographs are taken, they are developed and then scanned into a computer where they are stitched together by the stitcher program.

Although the photographs provided through the use of the extra equipment creates satisfactory composite images, there are several drawbacks to this approach. One drawback is that typical camera owners do not generally travel with a tripod. Therefore,

when a user discovers a scene that is a good candidate for a composite image, the user either does not attempt to take overlapping images, or the images that are taken are not properly overlapped to generate the composite image. And even in instances where the user has a tripod, the user may not have the mechanical alignment device, or may not have the expertise to use the device correctly.

Accordingly, what is needed is a method and system for assisting a user in manually capturing overlapping images for composite image generation without the use of extra equipment. The present invention addresses such a need.

SUMMARY OF THE INVENTION

The present invention provides a method and system for assisting a user in manually capturing overlapping images for composite image generation using a camera. The method and system includes dividing the view finder into a first and second zone in response to the user capturing a first image. The portion of the first image that is to overlap with the next image is then displayed in the first zone of the view finder, while a live image is displayed in the second zone.

According to the system and method disclosed herein, displaying the two zones in the view finder enables the user to align the live image with the first image without the need for extra equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a digital camera that operates in accordance with the present invention.

FIG. 2 is a block diagram of the preferred embodiment for the imaging device of FIG. 1.

FIG. 3 is a block diagram of the preferred embodiment for the computer of FIG. 1.

FIG. 4 is a memory map showing the preferred embodiment of the Dynamic Random-Access-Memory (DRAM).

FIG. 5 is a diagram depicting a user interface for the digital camera.

FIGS. 6A and 6B are diagrams illustrating the capture of a series of overlapping

images by a camera for use in composite image generation.

FIG. 7 is a flow chart depicting the process of assisting in the manual capture of overlapping images for composite image generation in accordance with the present invention.

FIG. 8 is a diagram showing an example scene that may be used to create a panorama using three overlapping images.

FIGS. 9A and 9B are diagrams showing a camera view finder divided into two zones in accordance with the present invention.

FIGS 10-12 are diagrams illustrating the processing of the input buffers and frame buffers to support the display of zones in the camera view finder.

DESCRIPTION OF THE INVENTION

The present invention relates to an improvement in digital cameras. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiment will be readily apparent to those skilled in the art and the generic principles herein may be applied to other embodiments. Thus, the present invention is not intended to be limited to the embodiment shown but is to be accorded the widest scope consistent with the principles and features described herein.

The present invention is a digital camera that includes a method and system for capturing overlapping images for composite image generation.

A digital camera architecture has been disclosed in co-pending U.S. Patent Application Serial No. _____, entitled "A System And Method For Using A Unified Memory Architecture To Implement A Digital Camera Device," filed on ____, 1996, and assigned to the Assignee of the present application. The Applicant hereby incorporates the co-pending application by reference, and reproduces portions of that application herein with reference to FIGS. 1-3 for convenience.

Referring now to FIG. 1, a block diagram of a camera 110 is shown according to the present invention. Camera 110 preferably comprises an imaging device 114, a system bus 116 and a computer 118. Imaging device 114 is optically coupled to an object 112

and electrically coupled via system bus 116 to computer 118. Once a photographer has focused imaging device 114 on object 112 and, using a capture button or some other means, instructed camera 110 to capture an image of object 112, computer 118 commands imaging device 114 via system bus 116 to capture raw image data representing object 112. The captured raw image data is transferred over system bus 116 to computer 118 which performs various image processing functions on the image data before storing it in its internal memory. System bus 116 also passes various status and control signals between imaging device 114 and computer 118.

Referring now to FIG. 2, a block diagram of the preferred embodiment of imaging device 114 is shown. Imaging device 114 preferably comprises a lens 220 having an iris, a filter 222, an image sensor 224, a timing generator 226, an analog signal processor (ASP) 228, an analog-to-digital (A/D) converter 230, an interface 232, and one or more motors 234.

U.S. Patent Application Serial No. 08/355,031, entitled "A System and Method For Generating a Contrast Overlay as a Focus Assist for an Imaging Device," filed on December 13, 1994, is incorporated herein by reference and provides a detailed discussion of the preferred elements of imaging device 114. Briefly, imaging device 114 captures an image of object 112 via reflected light impacting image sensor 224 along optical path 236. Image sensor 224 responsively generates a set of raw image data representing the captured image 112. The raw image data is then routed through ASP 228, A/D converter 230 and interface 232. Interface 232 has outputs for controlling ASP 228, motors 234 and timing generator 226. From interface 232, the raw image data passes over system bus 116 to computer 118.

Referring now to FIG. 3, a block diagram of the preferred embodiment for computer 118 is shown. System bus 116 provides connection paths between imaging device 114, power manager 342, central processing unit (CPU) 344, dynamic random-access memory (DRAM) 346, input/output interface (I/O) 348, read-only memory (ROM) 350, and buffers/connector 352. Removable memory 354 connects to system bus 116 via buffers/connector 352. Alternately, camera 110 may be implemented without removable memory 354 or buffers/connector 352.

Power manager 342 communicates via line 366 with power supply 356 and

coordinates power management operations for camera 110. CPU 344 typically includes a conventional processor device for controlling the operation of camera 110. In the preferred embodiment, CPU 344 is capable of concurrently running multiple software routines to control the various processes of camera 110 within a multi-threading environment. DRAM 346 is a contiguous block of dynamic memory which may be selectively allocated to various storage functions. LCD controller 390 accesses DRAM 346 and transfers processed image data to LCD view finder 402 for display, as explained further below.

I/O 348 is an interface device allowing communications to and from computer 118. For example, I/O 348 permits an external host computer (not shown) to connect to and communicate with computer 118. I/O 348 also permits a camera 110 user to communicate with camera 110 via an external user interface and via an external display panel, referred to as a view finder.

ROM 350 typically comprises a conventional nonvolatile read-only memory which stores a set of computer-readable program instructions to control the operation of camera 110. Removable memory 354 serves as an additional image data storage area and is preferably a non-volatile device, readily removable and replaceable by a camera 110 user via buffers/connector 352. Thus, a user who possesses several removable memories 354 may replace a full removable memory 354 with an empty removable memory 354 to effectively expand the picture-taking capacity of camera 110. In the preferred embodiment of the present invention, removable memory 354 is typically implemented using a flash disk.

Power supply 356 supplies operating power to the various components of camera 110. In the preferred embodiment, power supply 356 provides operating power to a main power bus 362 and also to a secondary power bus 364. The main power bus 362 provides power to imaging device 114, I/O 348, ROM 350 and removable memory 354. The secondary power bus 364 provides power to power manager 342, CPU 344 and DRAM 346.

Power supply 356 is connected to main batteries 358 and also to backup batteries 360. In the preferred embodiment, a camera 110 user may also connect power supply 356 to an external power source. During normal operation of power supply 356, the main

batteries 358 provide operating power to power supply 356 which then provides the operating power to camera 110 via both main power bus 362 and secondary power bus 364. During a power failure mode in which the main batteries 358 have failed (when their output voltage has fallen below a minimum operational voltage level) the backup batteries 360 provide operating power to power supply 356 which then provides the operating power only to the secondary power bus 364 of camera 110.

Referring now to FIG. 4A, a memory map showing the preferred embodiment of dynamic random-access-memory (DRAM) 346 is shown. In the preferred embodiment, DRAM 346 includes RAM disk 532, a system area 534, and working memory 530.

RAM disk 532 is a memory area used for storing raw and compressed image data and typically is organized in a "sectored" format similar to that of conventional hard disk drives. In the preferred embodiment, RAM disk 532 uses a well-known and standardized file system to permit external host computer systems, via I/O 348, to readily recognize and access the data stored on RAM disk 532. System area 534 typically stores data regarding system errors (for example, why a system shutdown occurred) for use by CPU 344 upon a restart of computer 118.

Working memory 530 includes various stacks, data structures and variables used by CPU 344 while executing the software routines used within computer 118. Working memory 530 also includes input buffers 538 for initially storing sets of raw image data received from imaging device 114, and frame buffers 536 for temporarily storing image data during the image processing and compression process.

In a preferred embodiment, the conversion process is performed by a live view generation program, which is stored in ROM 350 and executed on CPU 344. However, the conversion process can also be implemented using hardware. Referring again to FIG. 3, during the execution of the live view generation program, the CPU 344 takes the raw image data from the input buffers 538 in CCD format and performs color space conversion on the data. The conversions process performs gamma correction and converts the raw CCD data into either a RGB or YCC format which is compatible with the LCD view finder 402 display. After the conversion, CPU 344 stores the image data in the frame buffers 536. The LCD controller 390 then transfers the processed image data from the frame buffers to the LCD view finder 402 (via an optional analog converter) for

display.

Referring now to FIG. 4B, the contents of input buffers 538 and the frame buffers 536 are shown. In a preferred embodiment, both the input buffers 538 and the frame buffers 536 utilize two separate buffers, called ping-pong buffers, to improve the display speed of the digital camera and to prevent the tearing of the image in the view finder 402. As shown, input buffers 538 include an input buffer A and an input buffer B, and frame buffers 536 include a frame buffer A and a frame buffer B.

The input buffers A and B alternate between an input cycle and a processing cycle. During the input cycle, the input buffers 538 are filled with raw image data from the image device 114, and during the processing cycle, CPU 344 processes the raw data and transmits the processed data to the frame buffers 536. More specifically, while input buffer A is filling with image data, the data from input buffer B is processed and transmitted to frame buffer B. At the same time, previously processed data in frame buffer A is output to the LCD view finder 402 for display. While input buffer B is filling with image data, the data from input buffer A is processed and transmitted to frame buffer A. At the same time, previously processed data in frame buffer B is output to the LCD view finder 402 for display.

FIG. 5 is a diagram depicting a user interface 400 for the digital camera as described in co-pending U.S. Patent Application Serial No. ____, entitled "A Method and System For Displaying Images In The Interface of a Digital Camera," which is assigned to the Assignee of the present application and incorporated herein by reference. The user interface includes the LCD view finder 402 (hereinafter "view finder"), an image capture button called a photo button 404, a four-way navigation control button 406, a menu button 408, a menu area 410 within the view finder 402, and function keys 412. The user interface 400 may also include an optional sound button 414, and a mode button 416.

The user interface 400 operates in two modes: live view mode and review mode. In a preferred embodiment, the photo button 404 is a two-position button. The live view mode begins when a user aims the camera at an object 112 and presses the photo button 404 into the first position. Once this occurs, the view finder 402 displays a live image of the object 112 as shown through the camera's imaging device 114. The user may then press the photo button 404 into the second position to capture the image shown in the

view finder 402. Review mode begins by pressing any other button on the interface 400.

Once the digital camera 110 is placed in the review mode, the view finder 402 displays a series of cells 420 that represent the digital images that have been captured in the digital camera. The view finder 402 is shown here as displaying nine image cells 420. Each cell 420 displays a small-sized image corresponding to one of the captured images. The user may navigate through the series of displayed cells 420 in the view finder 402 using the four-way navigation control button 406. As the user navigates through the cells 420, the old image cells 420 are scrolled-off the view finder 402 and replaced by new image cells 420 representing other images stored in the camera.

The present invention provides a method and system for assisting a user in manually capturing a series of overlapping images in order to create a single composite image or panorama. Although the present invention will be explained with reference to the digital camera described herein, one with ordinary skill in the art will recognize that the method and system of the present invention will function with a conventional camera equipped with an electric view finder to create a panorama as well.

FIGS. 6A and 6B are diagrams illustrating the capture of a series of overlapping images by a camera for use in composite image generation. FIG. 6A is a top view showing the camera rotated into three positions to capture three corresponding images. FIG. 6B shows the area of overlap 440a between image 1 and image 2, and the area of overlap 440b between image 2 and image 3. In a preferred embodiment, the generation of a composite image from overlapping images typically requires an overlap area 440 of approximately twenty-five percent between two images.

As stated above, past techniques for enabling a user to capture overlapping images have required extra equipment to place the camera into pre-set positions in order to automatically align the overlapping images. The present invention, in contrast, provides a method and system for assisting a user to manually align and capture the overlapping images without extra equipment. This is accomplished by dividing the view finder 402 of the camera into two zones, where one zone displays a live image and the other zone displays a still image of the overlapping portion of the last captured image. This enables the user to manually align the live image with the still image without the need for alignment equipment, such as a tripod etc.

FIG. 7 is a flow chart depicting the process of assisting in the manual capture of overlapping images for composite image generation in a preferred embodiment of the present invention. The process begins when a user depresses a function button on the camera to start the composite image capture process in step 550. In a preferred embodiment, the digital camera will then display a prompt in the view finder 402 requesting the user to capture the first image of the panorama in step 552. In response, the user aims the camera at a desired scene and captures the first image of the panorama in step 554.

FIG. 8 is a diagram showing an example scene that may be used to create a panorama using three overlapping images, as shown in FIGS. 6A and 6B. Although a three image example is used here, a composite image maybe made with any number of overlapping images. As shown, the user captures the first image by placing the camera into position 1 so that one edge of the scene appears in the view finder 402 (the left edge in this example).

Referring again to FIG. 7, after the first image is captured, the view finder 402 of the camera is divided into two separate zones in step 556 in accordance with the present invention.

FIGS. 9A and 9B are diagrams illustrating the camera view finder 402 divided into zones A and B. Referring again to FIG. 7, one of the zones in the view finder 402, zone A in this example, displays a portion of the previously captured image that overlaps the next image in step 558. The other zone, zone B, displays a live image of the scene as shown through the camera's imaging device in step 560.

Referring again to FIGS. 8 and 9A for example, after the first image is captured and after the user places the camera into position 2 (steps 558 and 560), a still image of the overlap area 440a of the first image is displayed in zone A of the view finder 402, while a live image of the next image in the scene is displayed in zone B.

In a preferred embodiment, zones A and B are shaped by a dividing line 580 comprising a series of darkened pixels. The dividing line 580 is shown here as interlocking cut-outs, but could also be drawn as a straight line, a diagonal line, or a zig-zag line, for instance.

Referring again to FIG. 7, after displaying the live image in zone B in step 560, the

user establishes horizontal and vertical alignment between the live image in zone B with the still image in zone A in step 562 by altering the position of the camera.

After aligning the live image with the still image in step 562, the user captures the second image of the panorama in step 564. If the user depresses a button indicating that the panorama capture is done in step 566, the process ends at step 568. Otherwise, the view finder 402 is again divided into two zones in step 556, and the process continues. This is shown in FIG. 9B which shows that after the user captures the second image from position 2, the overlap area 440b of the second image is displayed in zone A of the view finder 402, while zone B displays the live view of the scene in camera position 3.

According to the present invention, the dividing of the view finder 402 into separate zones is accomplished by manipulating the input buffers 538 and the frame buffers 536 (FIG. 4B). In a preferred embodiment, the input buffers 538 and the frame buffers 536 are manipulated by dividing each of the input buffers A and B and each of the frame buffers A and B into two zones (A and B) corresponding to the two zones in the view finder 402. This division of the input and frame buffers 538 and 536 is a multi-stage process. When the digital camera is in normal live view mode, the input and frame buffers 538 and 536 are processed as shown with reference to FIG. 4B.

After the user has initiated the composite image sequence, and has then captured the first image in the sequence, a post-capture process is performed on the input buffers 538 and the frame buffers 536 to display the overlap portion of the previously captured image in zone A of the view finder 402. Thereafter, the input buffers 538 and the frame buffers 536 are processed according to a modified live view process to display a view only in zone B of the view finder 402. In a preferred embodiment, the input buffers 538 and the frame buffers 536 are processed by the live view generation program running on CPU 344, but could also be processed using well known hardware operating in accordance with the present invention.

FIGS. 10 and 11 are block diagrams illustrating the post-capture processing of the input buffers 538 and the frame buffers 536. As shown, each of the input buffers A and B and each of the frame buffers A and B are divided into two zones (A and B) corresponding to the two zones in the view finder 402, where zone A corresponds to the overlap area of the previously captured image. To compute the display of zone A in the

view finder 402 if input buffer A is currently in a processing cycle, the CPU 344 processes the data from zone A of input buffer A and transfers the data to zone A of frame buffer A for output to the view finder 402. Alternatively, if input buffer B is currently in a processing cycle, the CPU 344 processes the data from zone A of input buffer B and transfers the data to zone A of frame buffer A. Referring to FIG. 11, the data transferred to zone A of frame buffer A is then copied to zone A of frame buffer B for output to zone A of the view finder 402. Next, the data for zone B of the view finder 402 must be processed.

FIG. 12 is a block diagram illustrating the modified live view processing of the input buffers 538 and the frame buffers 536 during composite image capture. As shown, the positioning of zone A and zone B in the input buffers A and B are switched during live view processing, and the object as seen through the camera's imaging device is input directly into zone B of both input buffers.

If input buffer A is currently in a processing cycle, the CPU 344 processes the data from zone B of input buffer A and transfers the data into zone B of frame buffer A for output to zone B of the view finder 402. If input buffer B is currently in a processing cycle, the CPU 344 processes the data from zone B of input buffer B and transfers the data into zone B of frame buffer B. This processing of zone B data from the input buffers 538 to the frame buffers 536 continues until the next image is captured. After the next image is captured, the overlap portion of the newly captured image is copied into zone A of the input buffers 538 for the post-capture process, and the above process is repeated until the user ends the composite image capture process.

A method and system for assisting a user in the capture of overlapping images for composite image generation has been disclosed which dispenses for the need of extra camera equipment. Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. For example, the dividing of the viewfinder into zones is not limited to two zones, but rather may include more than two. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.

CLAIMS

What is claimed is:

1. A method for assisting a user in manually capturing overlapping images for composite image generation using a camera, wherein the overlapping images including a first image and a second image, and the camera includes a view finder, the method comprising the steps of:

(a) dividing the view finder into a first and a second zone in response to the user capturing the first image;

(b) displaying a portion of the first image that is to overlap with the second image in the first zone; and

(c) displaying a live image in the second zone to enable the user to align the live image with the first image.

2. A method as in claim 1 further including the step of:

(d) capturing the live image to provide the second image.

3. A method as in claim 2 wherein step (a) includes the step of:

(a1) shaping the first zone and the second zone in the view finder using a contiguously shaped line.

4. A method as in claim 3 wherein step (a) is performed in response to the user initiating a composite image capture process in the camera.

5. A method as in claim 4 wherein step (a) further includes the step of prompting the user to capture the first image.

6. A method as in claim 5 further including the step of:

(e) repeating steps (a) through (d) until the user indicates the composite image process has completed.

7. A digital camera comprising:

an imaging device for capturing image data;

a memory for storing the image data from the imaging device;

a view finder; and

processing means coupled to the imaging device, the memory and to the view finder, the processing means functioning to divide the view finder into a first and a second zone in response to the user initiating a composite image capture process and capturing a first image, the processing means further functioning to display a portion of the first image that is to overlap with a second image in the first zone, and to display a live image in the second zone to enable the user to align the live image with the first image before capturing the live image.

8. The invention of claim 7 wherein the memory includes a first buffer and a second buffer, and wherein the first buffer stores the image data from imaging device, the processing means functioning to perform color space conversion on the image data to provide processed image data, and to store the processed image data in the frame buffer for output to the view finder.

9. The invention of claim 8 wherein the first buffer includes a first and second input buffer, and the second buffer includes a first and second frame buffer.

10. The invention of claim 9 wherein the first and second input buffers and the first and second frame buffers are divided into a first zone and a second zone corresponding to the view finder.

11. The invention of claim 10 wherein the digital camera further an LCD controller coupled to the memory and to the view finder for transferring the image data from the first and second frame buffers to the view finder for display.

12. The invention of claim 11 wherein the color space conversion converts the raw CCD data into one of a RGB and a YCC format.

13. The invention of claim 12 wherein the processing means comprises a software program.

14. The invention of claim 13 wherein the processing means comprises hardware.

15. The invention of claim 14 wherein the view finder includes a plurality of zones.

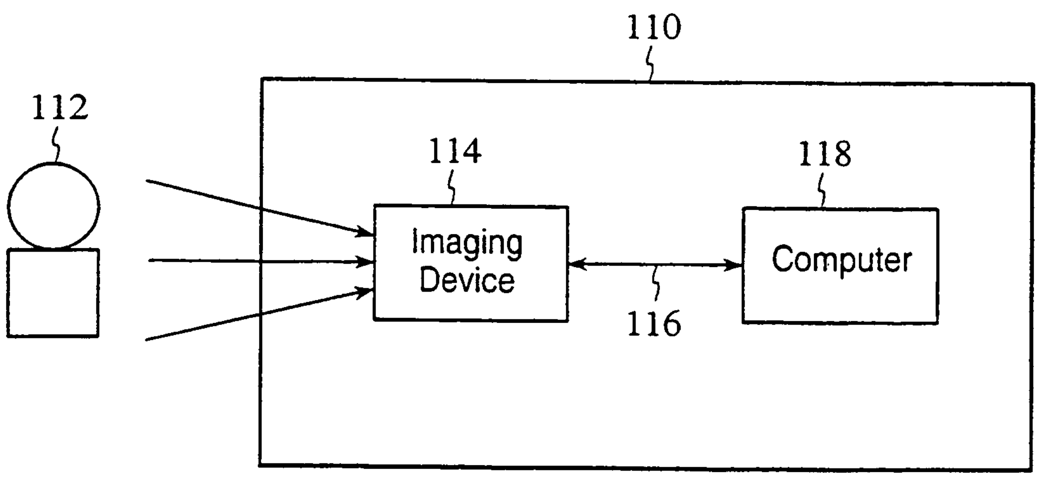


FIG. 1

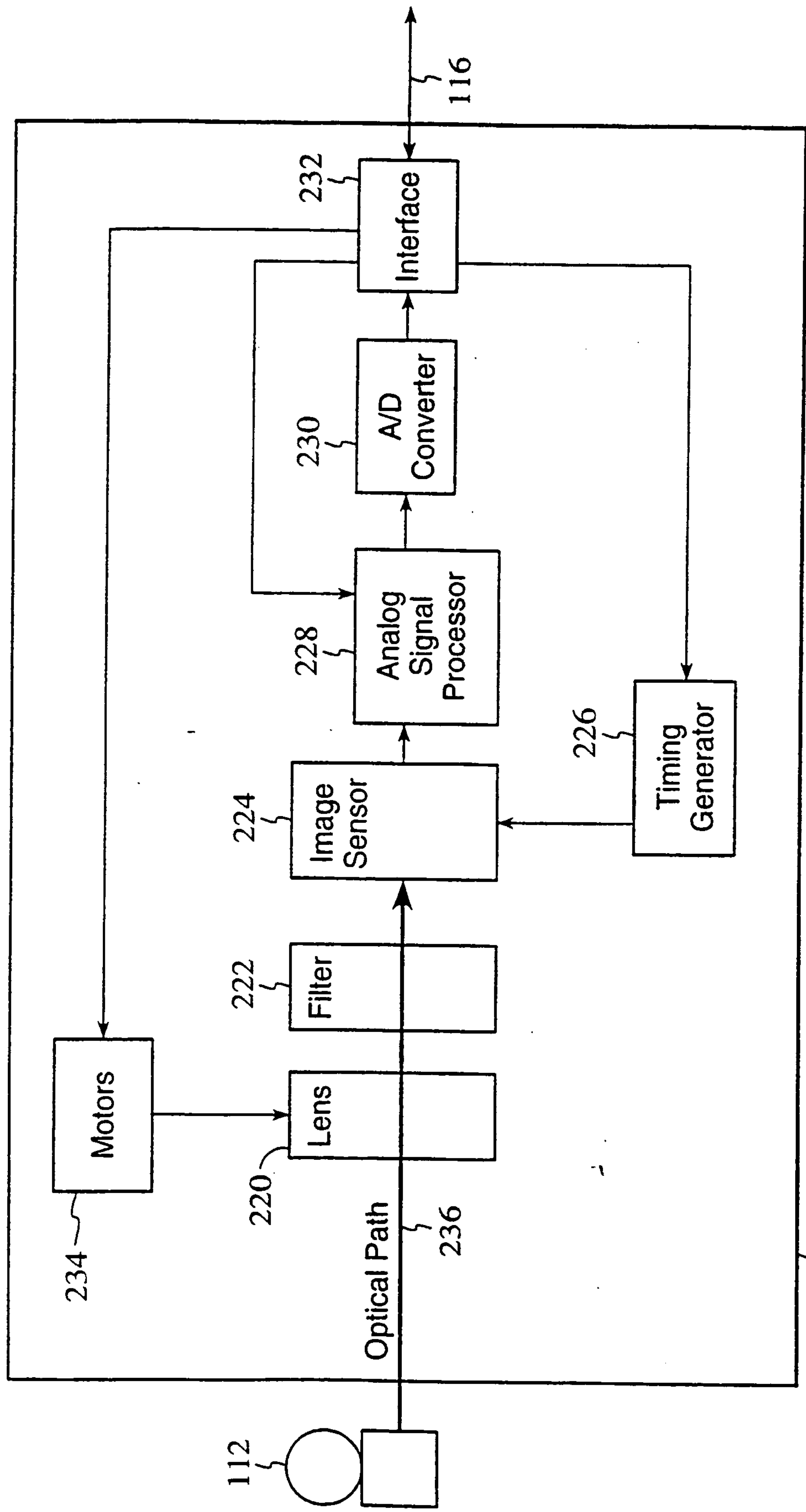

116
232
Interface
230
A/D Converter
228
Analog Signal Processor
226
Timing Generator
224
Image Sensor
222
Filter
Motors
Lens
220
234
Optical Path
236
114
112

FIG. 2

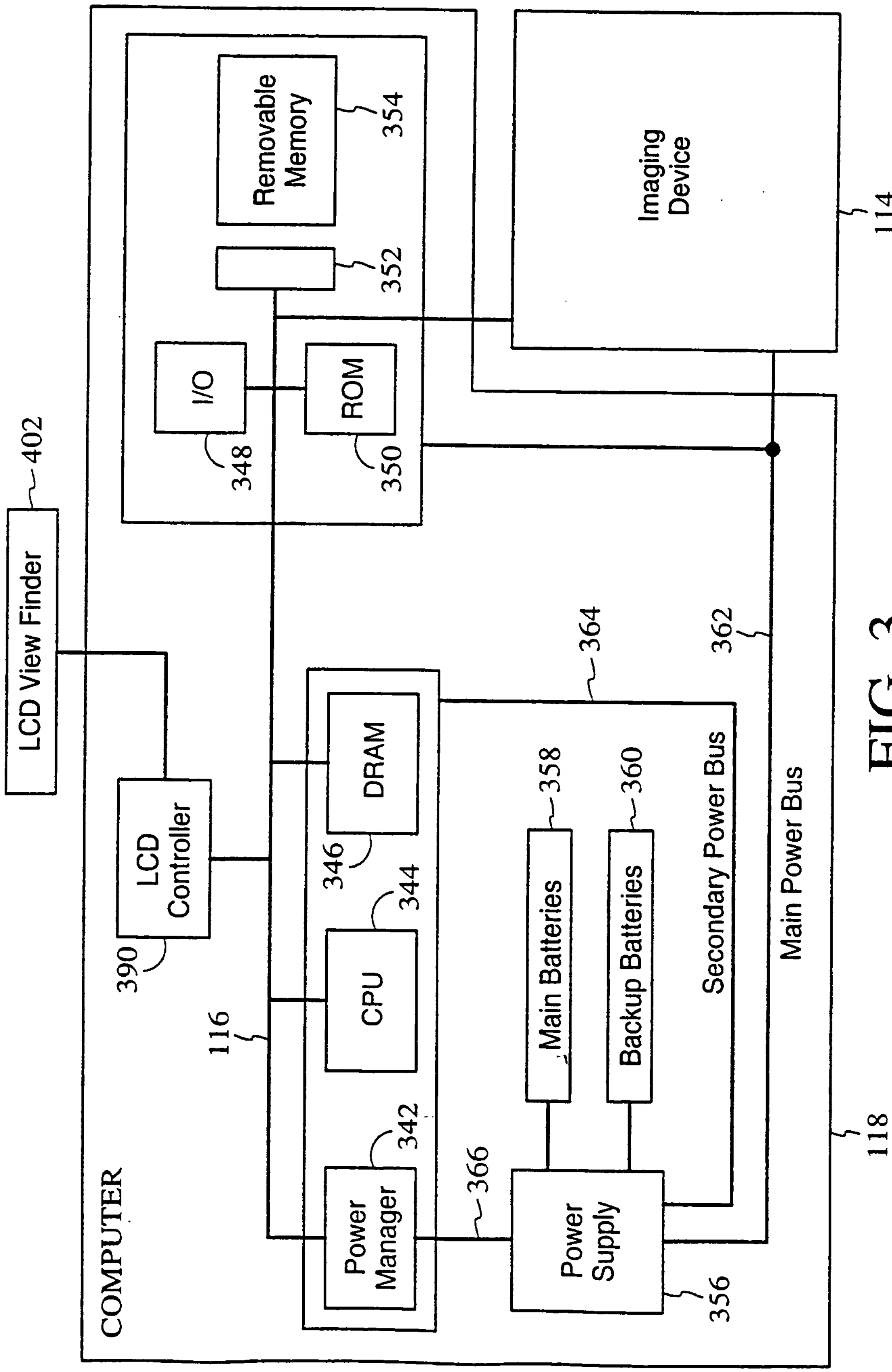

COMPUTER
LCD View Finder
402
LCD Controller
390
Removable Memory
354
352
I/O
348
ROM
350
Imaging Device
114
DRAM
346
CPU
344
116
Power Manager
342
366
Power Supply
356
Main Batteries
358
Backup Batteries
360
Secondary Power Bus
364
Main Power Bus
362
118

FIG. 3

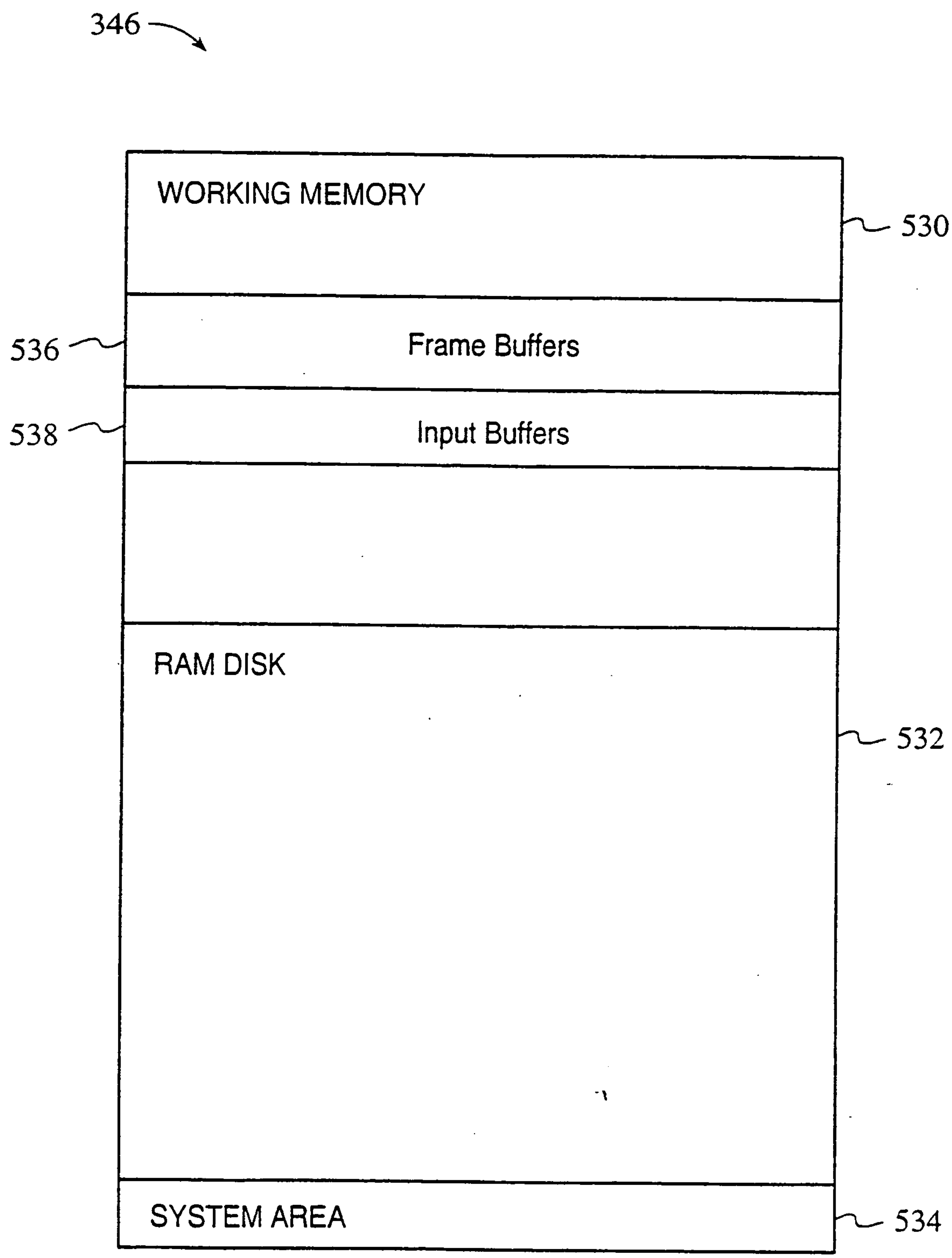

346
WORKING MEMORY
530
536
Frame Buffers
538
Input Buffers
RAM DISK
532
SYSTEM AREA
534

FIG. 4A

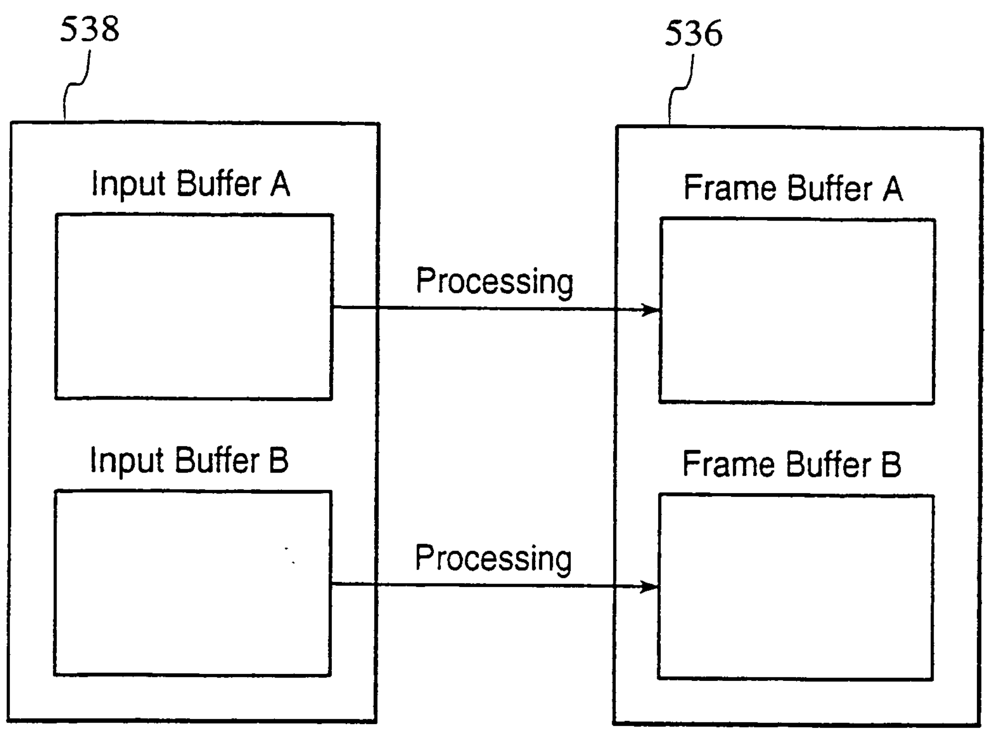
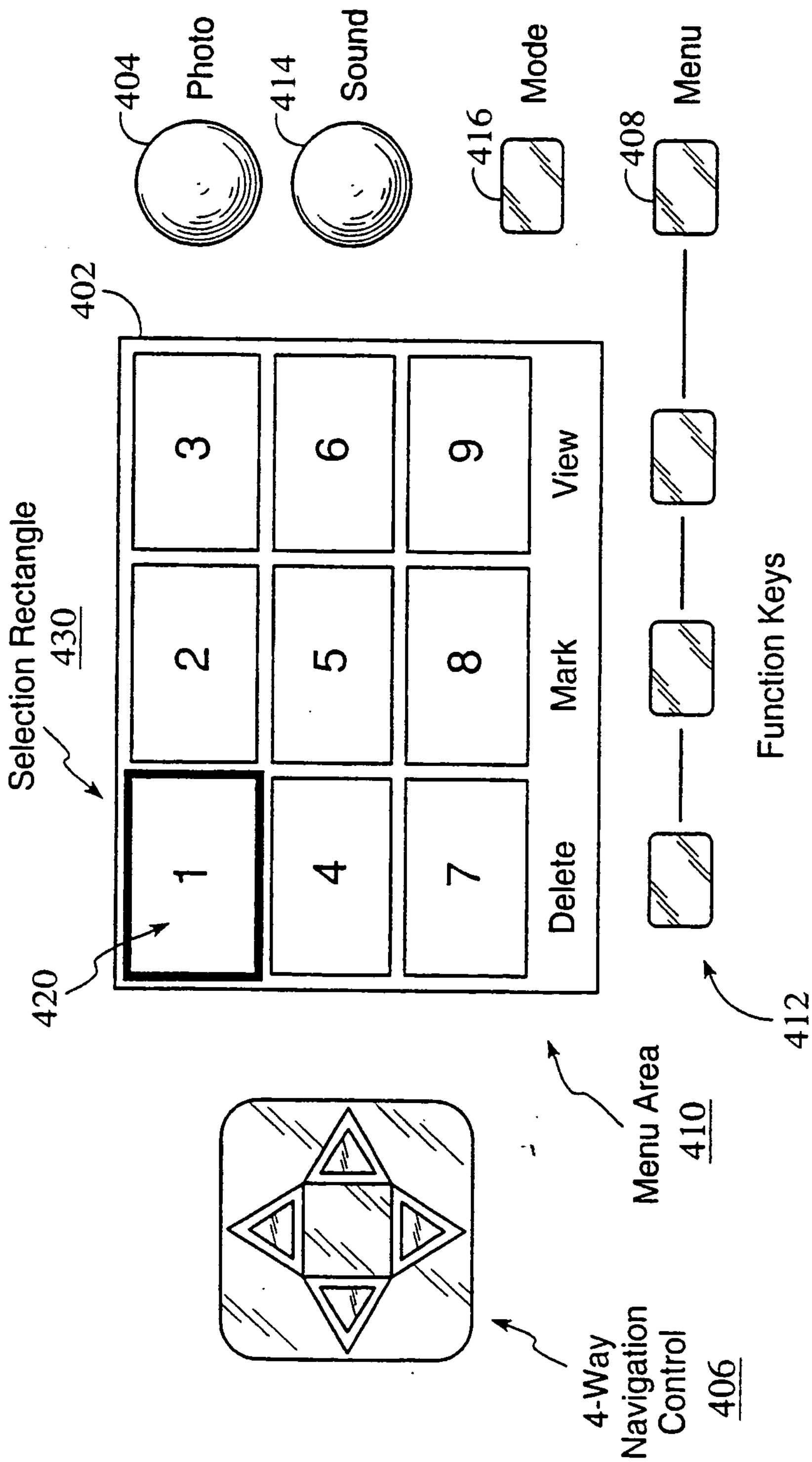

538
536
Input Buffer A
Input Buffer B
Processing
Processing
Frame Buffer A
Frame Buffer B

FIG. 4B


404
Photo
414
Sound
416
Mode
408
Menu
402
Selection Rectangle
430
1
2
3
4
5
6
7
8
9
Delete
Mark
View
420
Function Keys
412
Menu Area
410
4-Way
Navigation
Control
406

400

FIG. 5

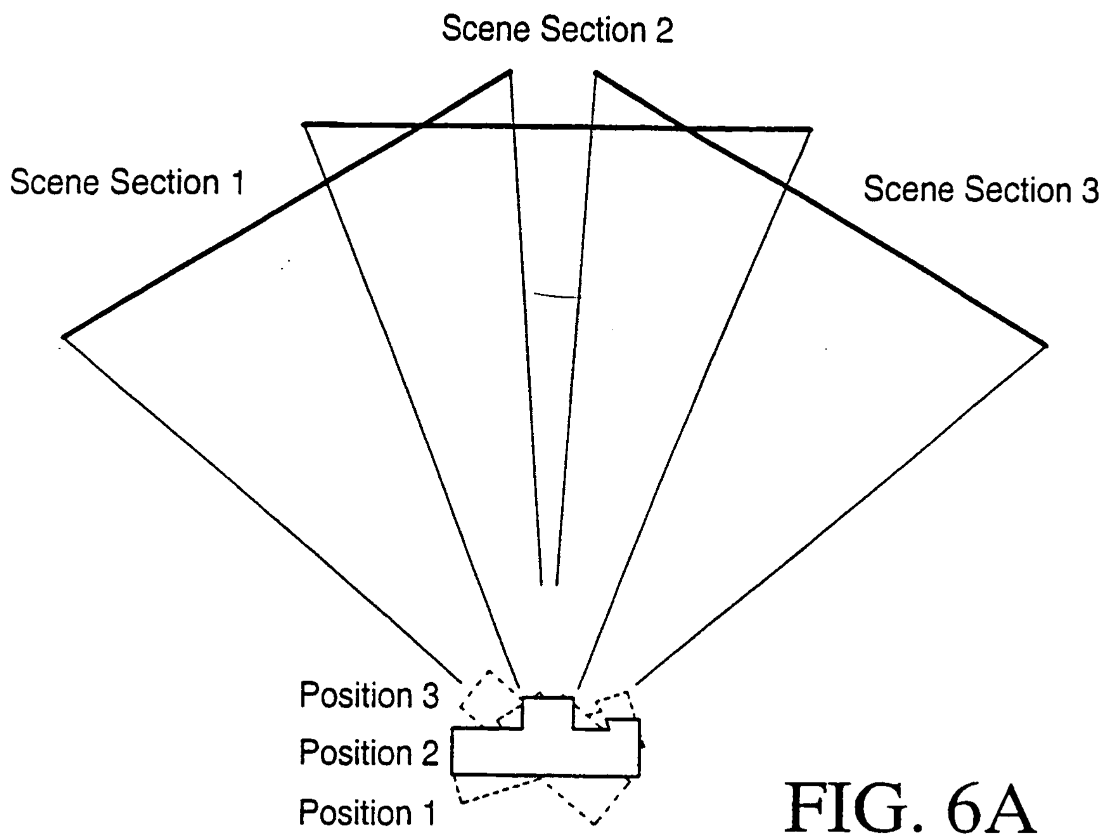

Scene Section 2
Scene Section 1
Scene Section 3
Position 3
Position 2
Position 1

FIG. 6A

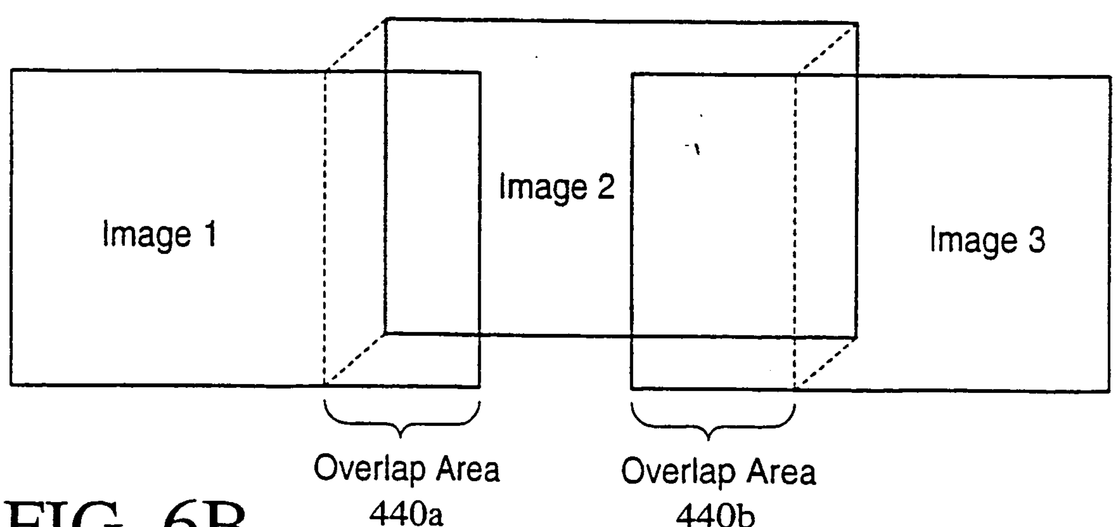


Image 1
Image 2
Image 3
Overlap Area
440a
Overlap Area
440b

FIG. 6B

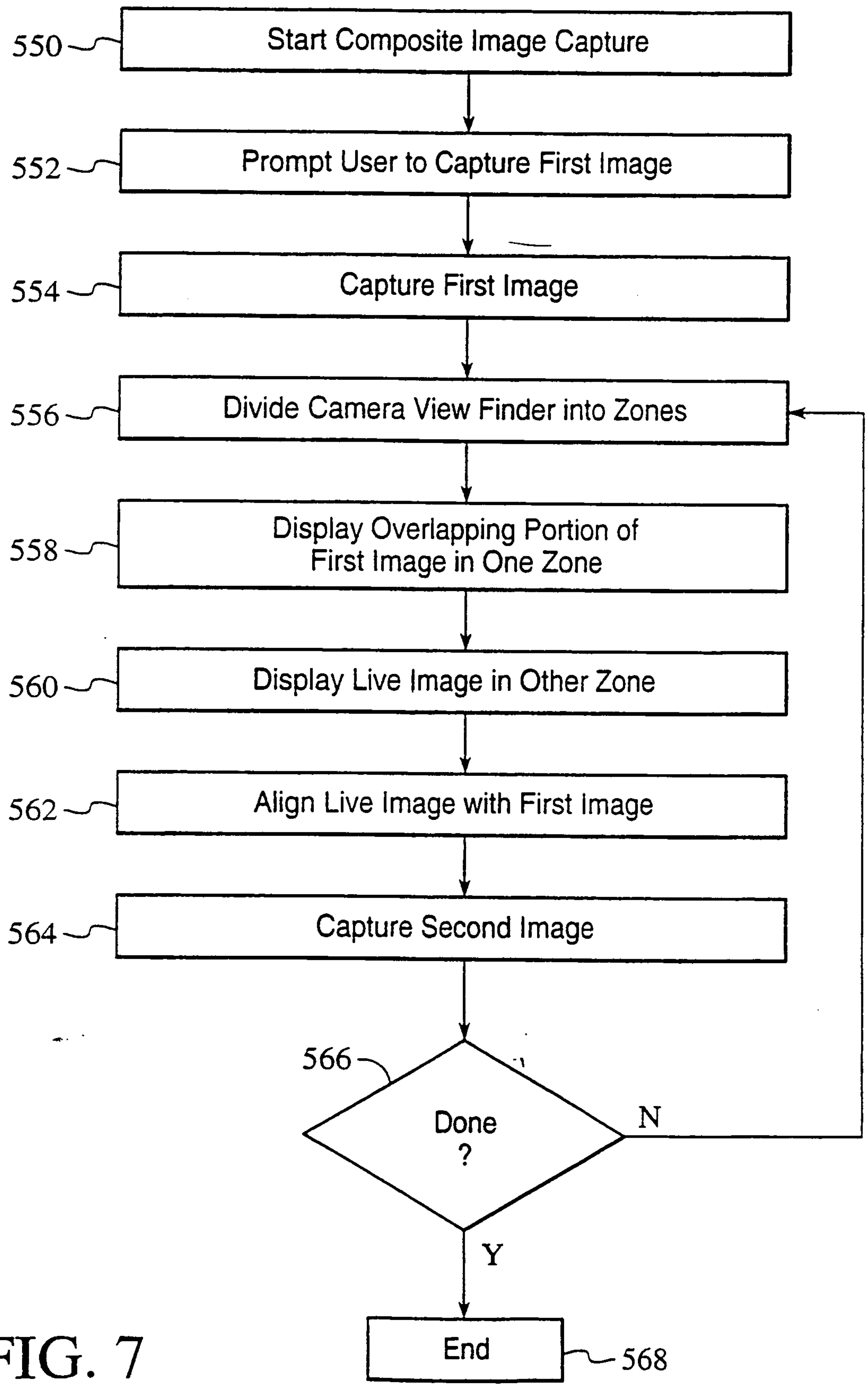

550
Start Composite Image Capture
552
Prompt User to Capture First Image
554
Capture First Image
556
Divide Camera View Finder into Zones
558
Display Overlapping Portion of First Image in One Zone
560
Display Live Image in Other Zone
562
Align Live Image with First Image
564
Capture Second Image
566
Done ?
N
Y
End
568

FIG. 7

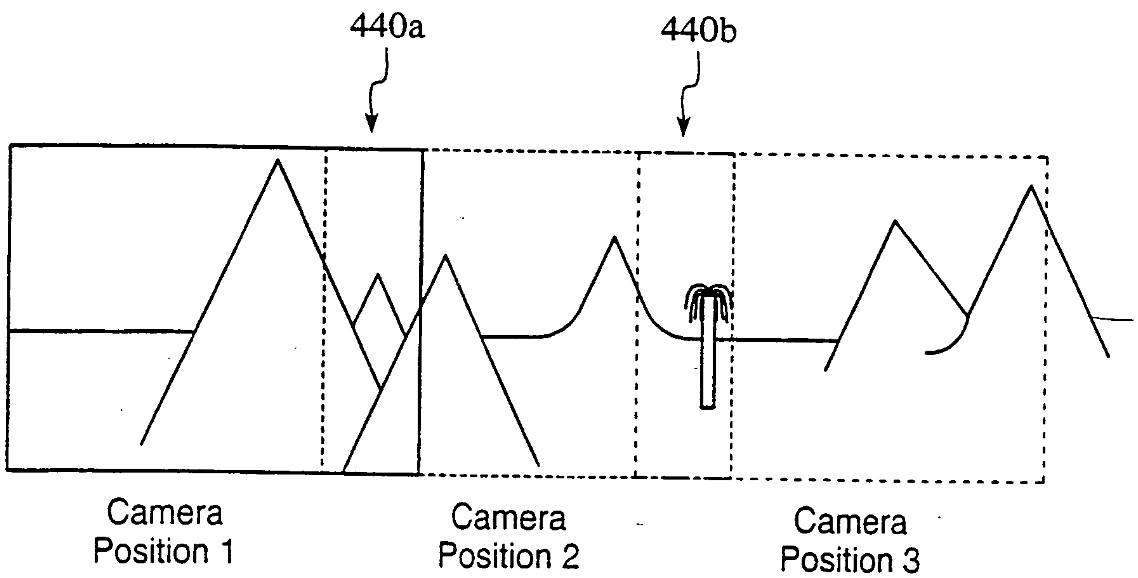


FIG. 8

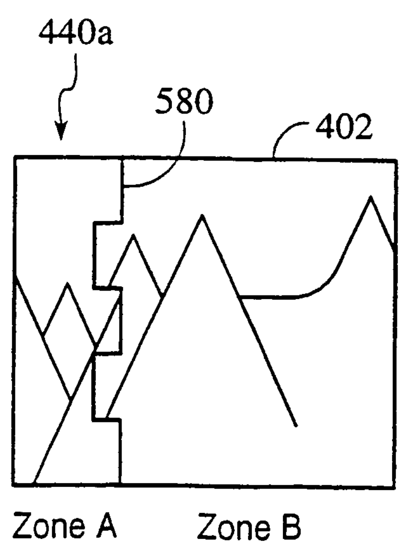


FIG. 9A

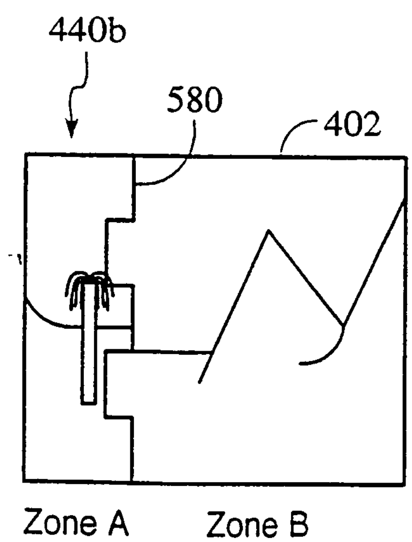
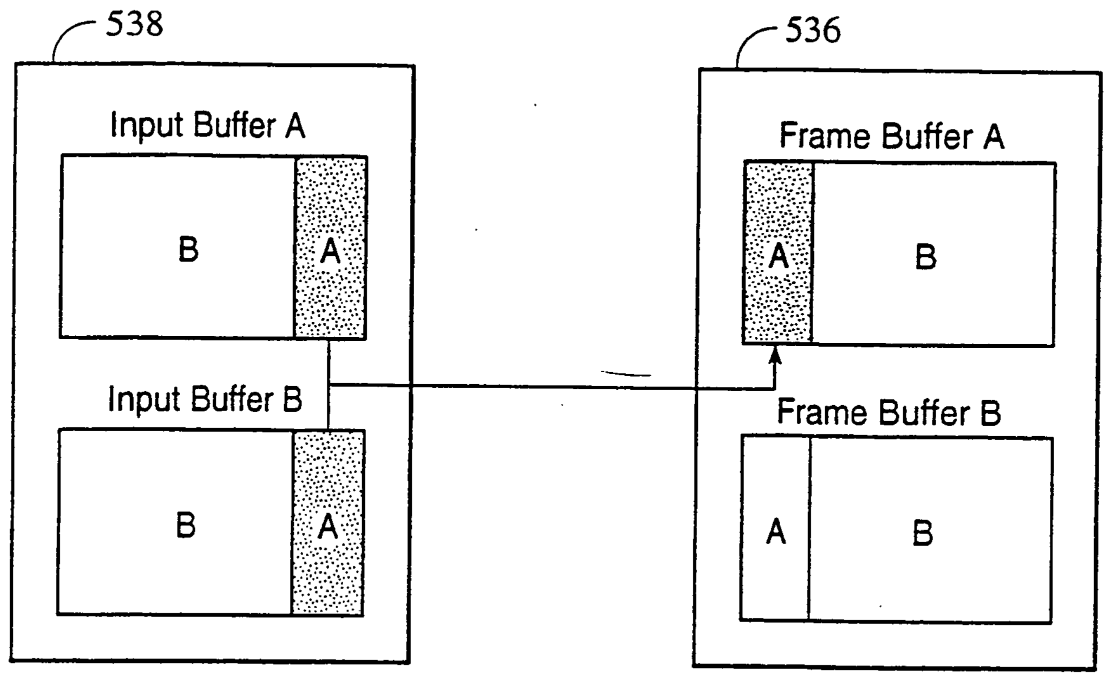
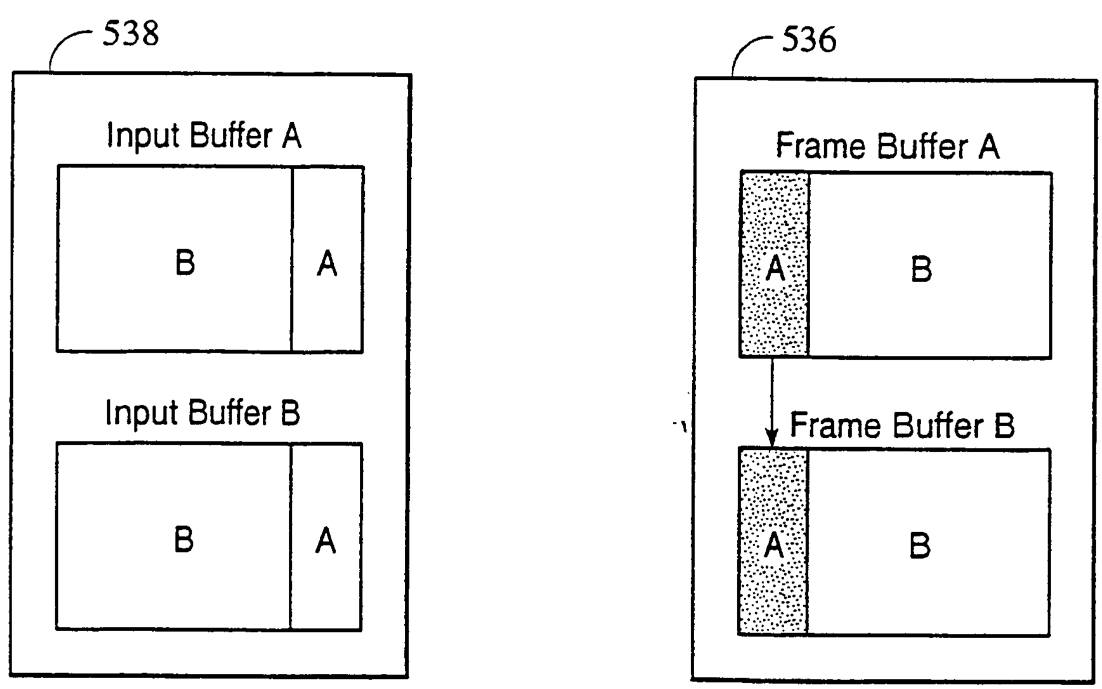


FIG. 9B



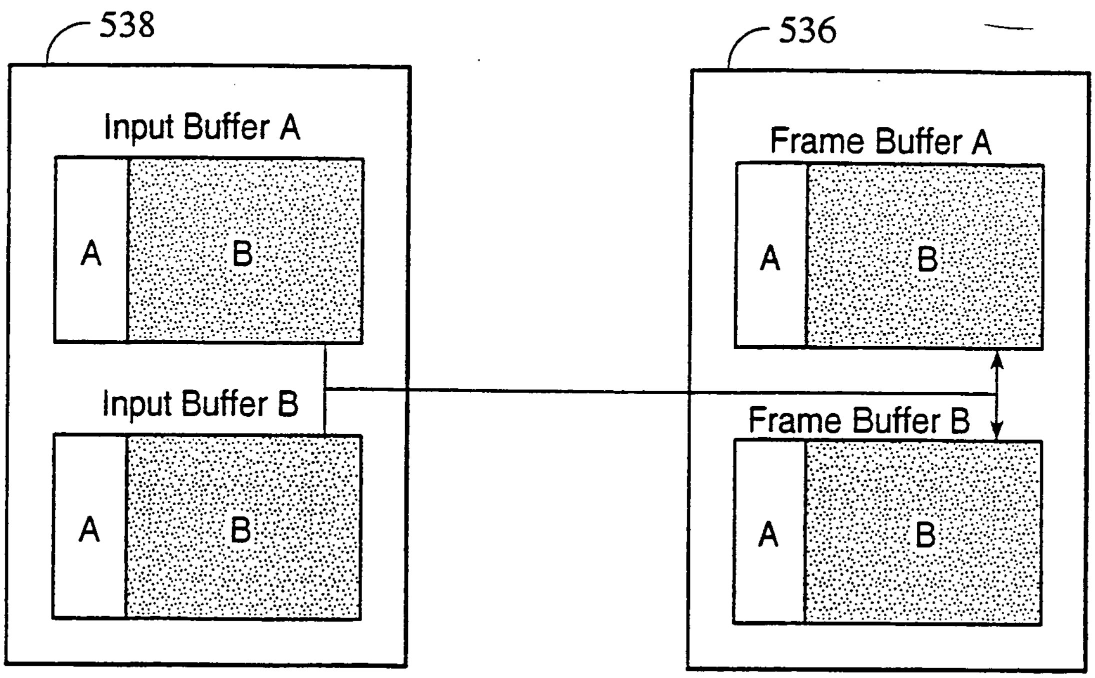
Post Capture Process

FIG. 10



Post Capture Process

FIG. 11



Live View Processing

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/22387

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04N 5/222, 5/335, 3/14; G09G 5/00
US CL :348/218,231,223,272,333

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/218,231,223,272,333

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,138,460 (EGAWA) 11 August 1992, Figures 2-4, 6 and 7, col.3, lines 13-46, col.4, lines 25-40.	1-7 ---- 8-15
Y	US, A, 5,194,944 (UCHIYAMA ET AL.) 16 March 1993, Figure 3.	8, 12
Y	US, A, 5,200,818 (NETA ET AL.) 06 April 1993, Figure 3.	9-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 FEBRUARY 1998	21.04.98

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